Observations on the development of Uncinula spiralis.[1]

B. T. GALLOWAY.

WITH PLATES XXXII AND XXXIII.

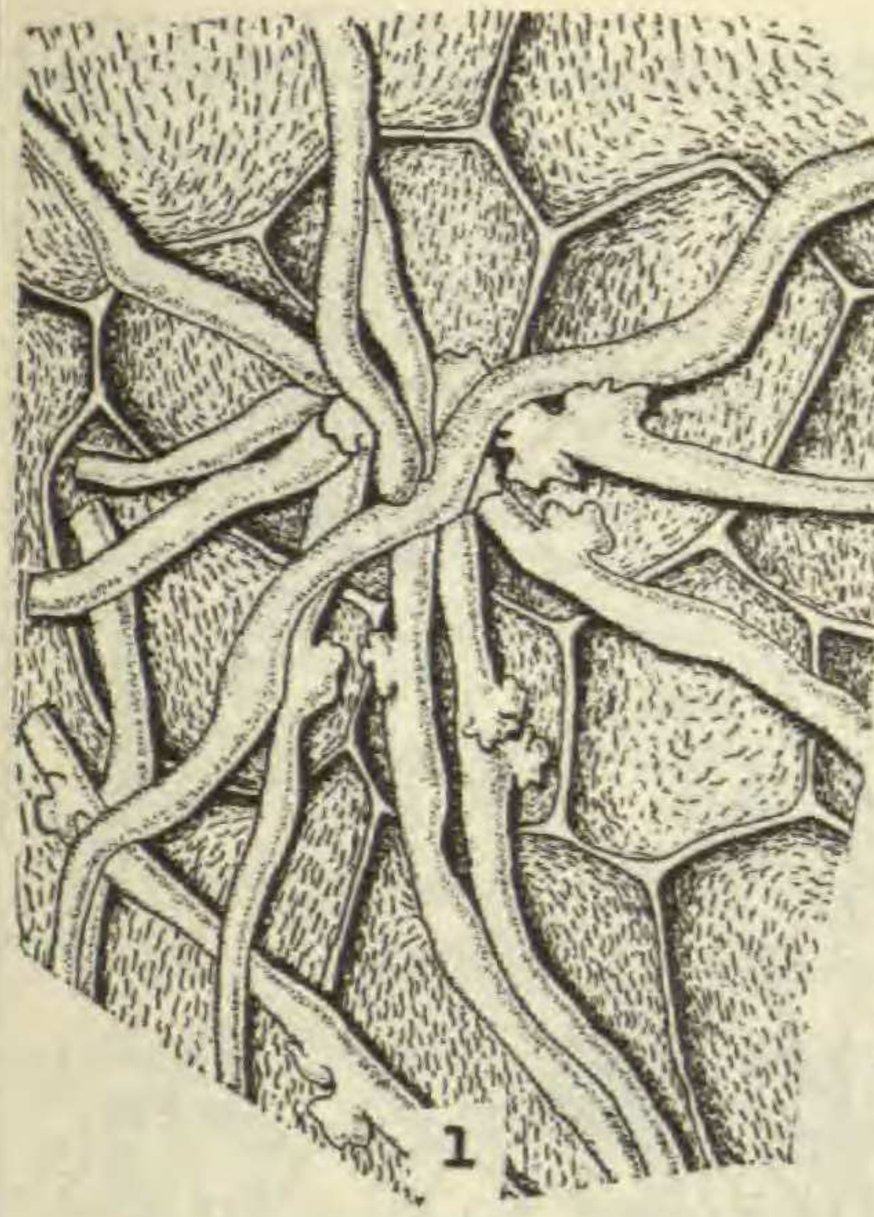
At the meeting of this Association held in Indianapolis in 1890, the writer presented a note on *Uncinula spiralis* B. & C., calling attention to a number of experiments which established the connection between the forms on Vitis and those on Ampelopsis. Since presenting the note in question some additional studies on the life history of the fungus have been made, and while these are not as complete as they might be, it is thought desirable to present the results here, especially as it is doubtful when further opportunities for work will be afforded.

The fungus in question, commonly called the grape powdery mildew, is widely distributed in this country, occurring on various species and varieties of Vitis and also on *Ampelopsis quinquefolia*. In California and elsewhere on the Pacific coast the fungus is especially prevalent on varieties of *Vitis vinifera*, and it also attacks these plants in the eastern United States when grown out of doors and in greenhouses. What is doubtless the same fungus occurs in Europe, where it has long been known as *Oidium Tuckeri*. The native spore form of this fungus was wanting, however, for a long time on European vines, and it is only recently that Prillieux[2] has noted its occurrence in France. According to Prillieux, the perithecia found in Europe do not differ materially from those occurring in this country, and so far as such evidence goes there seems no reason to doubt the statements of Viala, Scribner, and others, that the forms are identical. The present paper is concerned only with the development of the fungus in this country, the studies for the most part being made upon material from the eastern United States.

The Uncinula usually becomes sufficiently abundant to be easily found on cultivated varieties of grape, as well as on Ampelopsis, early in July. Toward the latter part of August

[1] Read before section G, A. A. A. S., Springfield meeting, August, 1895.

[2] Sur les perithéces de l'Uncinula spiralis en France et l'identité de l'Oidium Americain et de l'Oidium Européen. Bull. de la Soc. Mycologique de France **9:** 253. 1893.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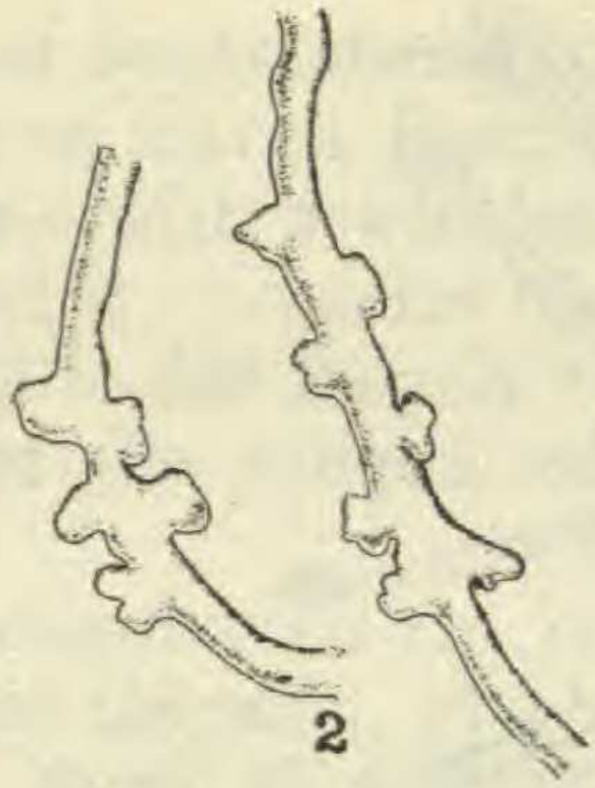
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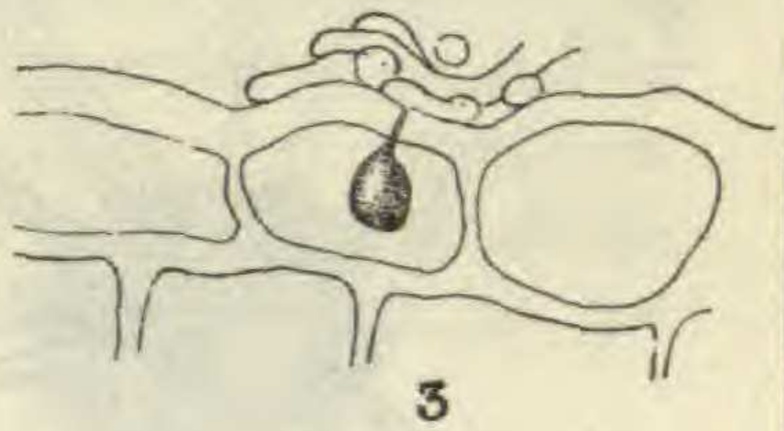
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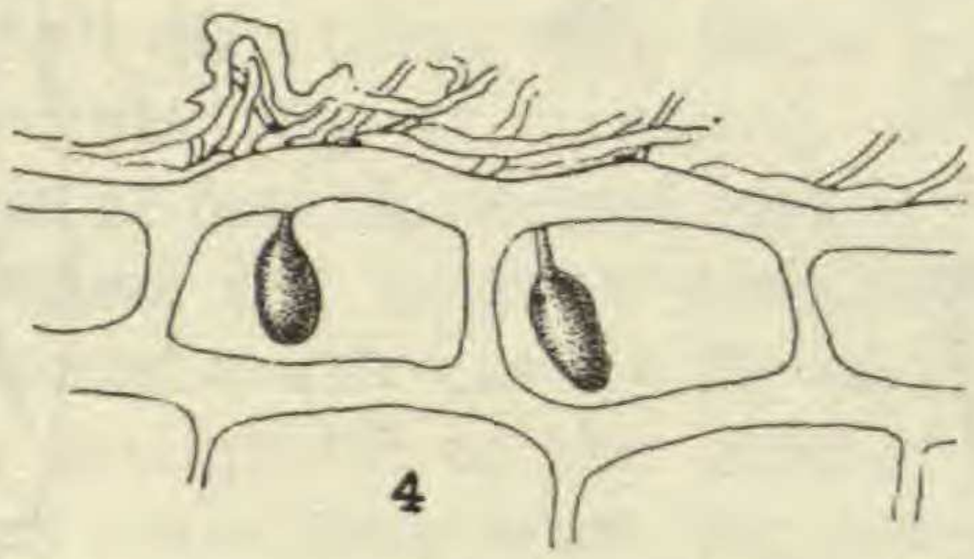
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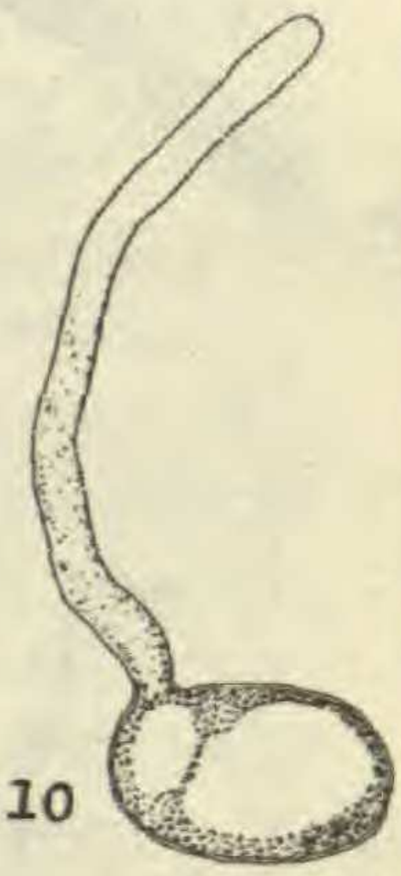
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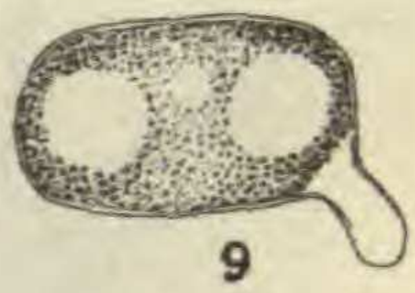
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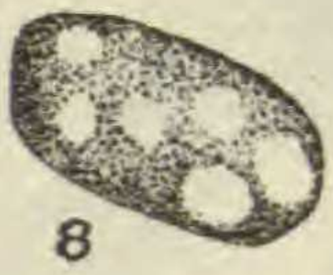
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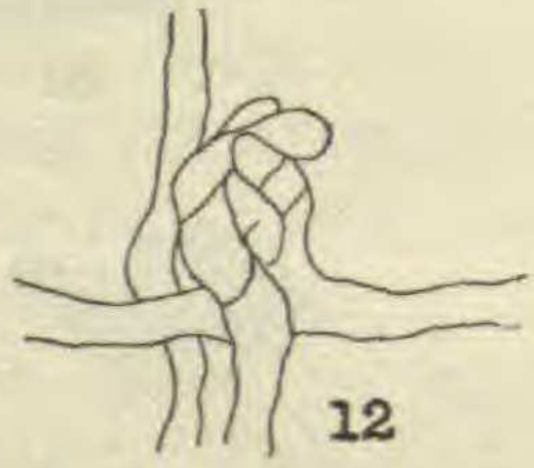
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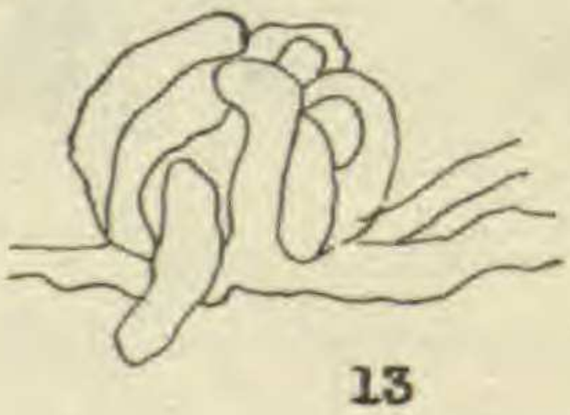
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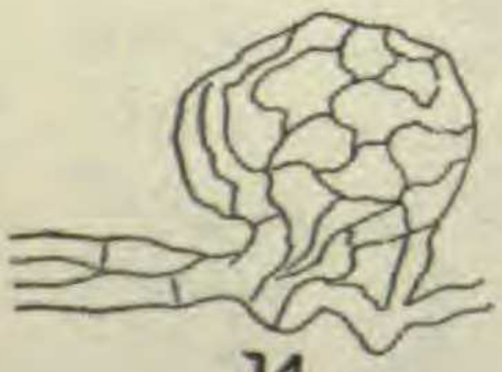
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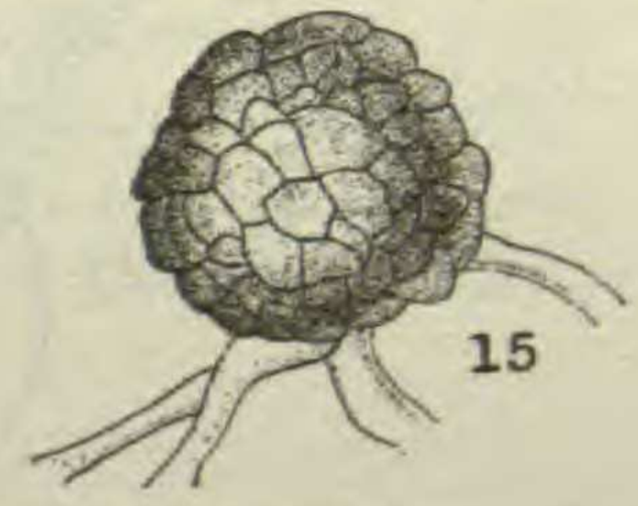
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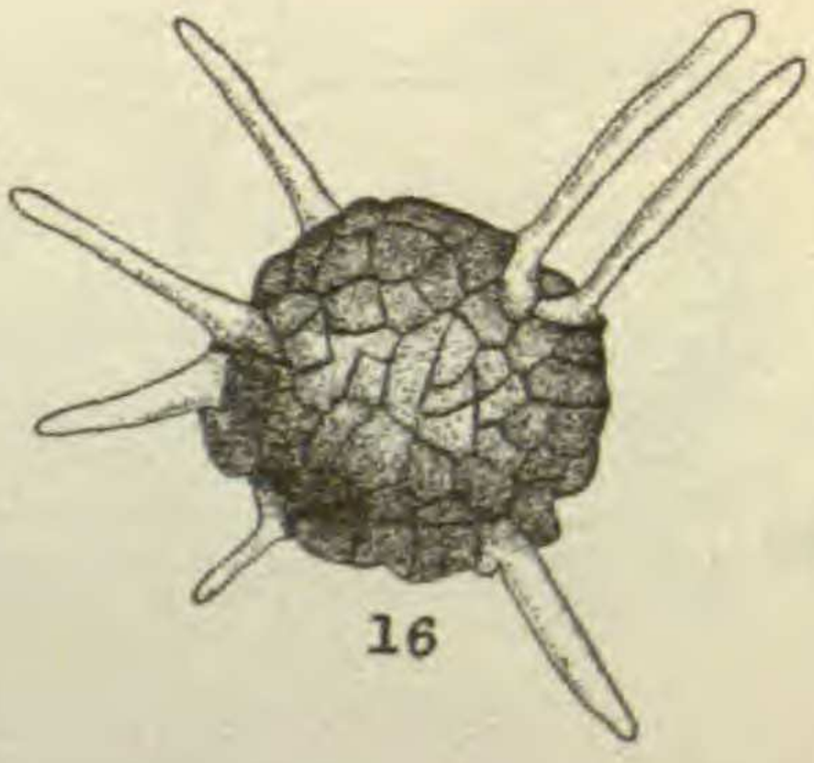
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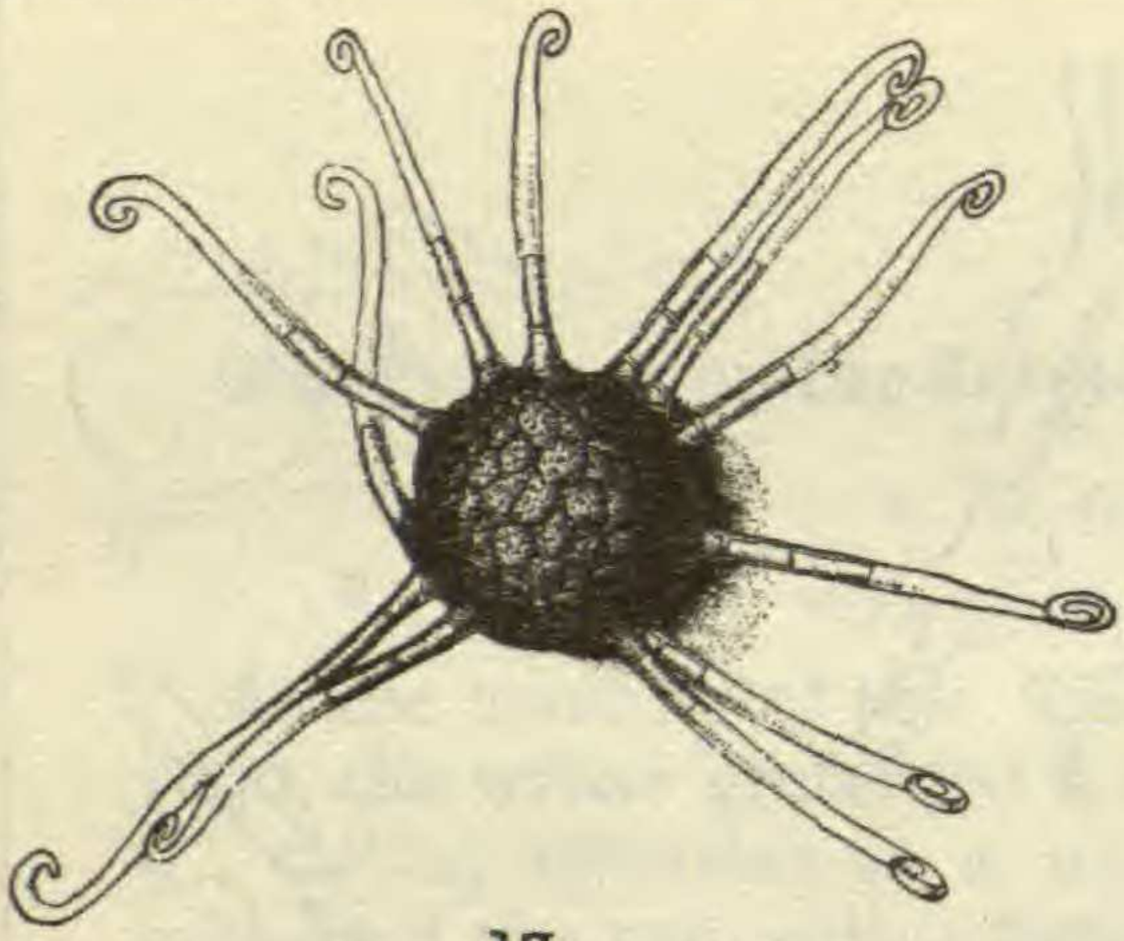
GALLOWAY on UNCINULA.



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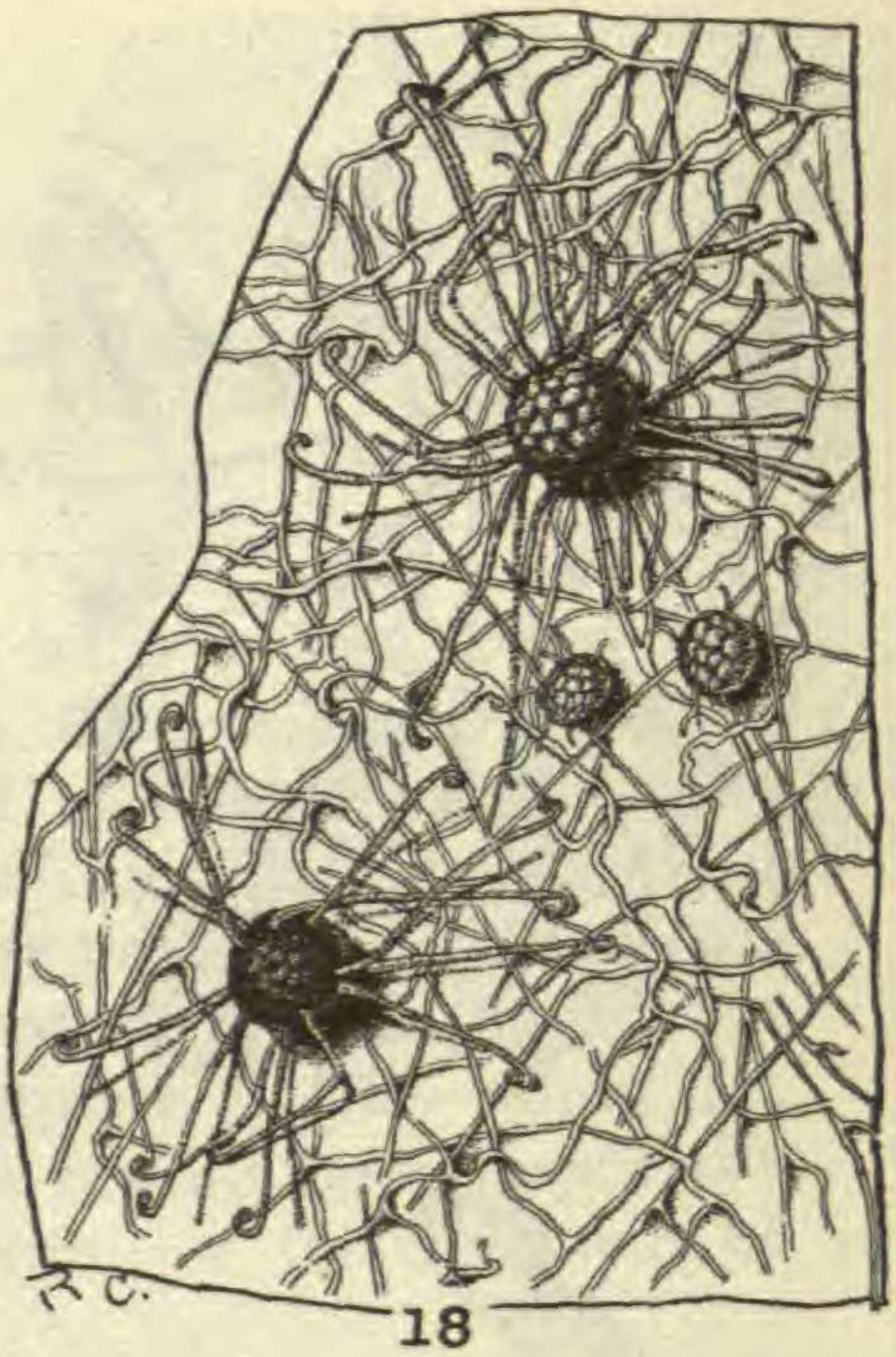

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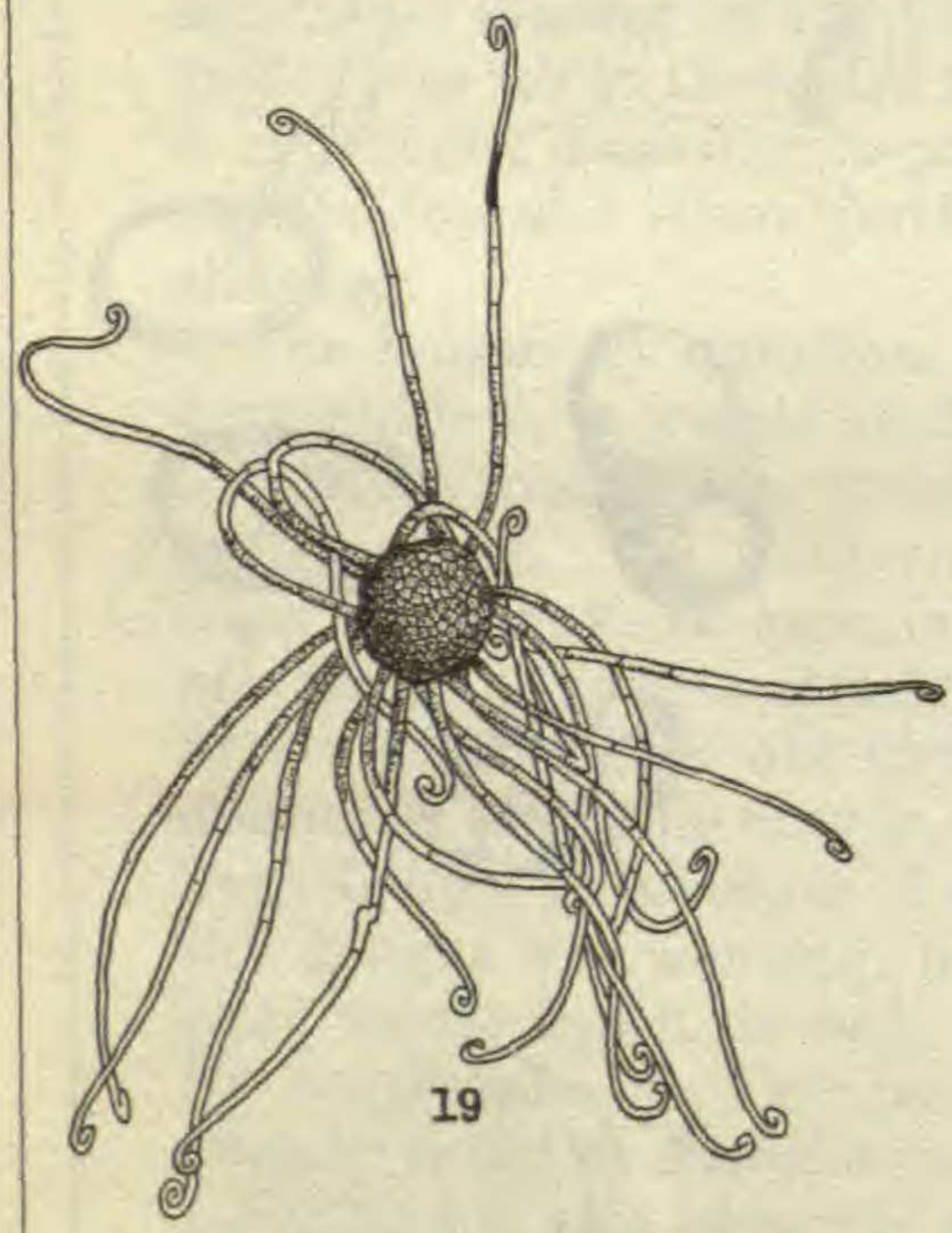

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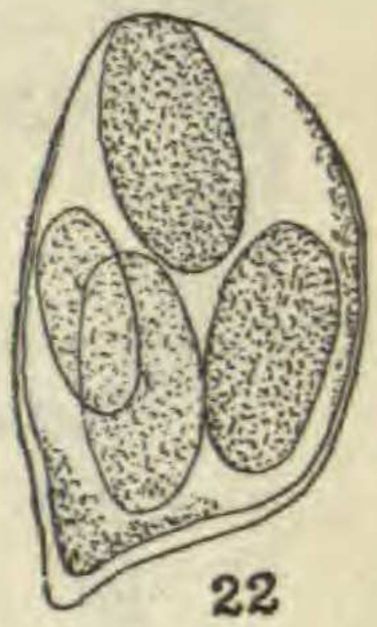

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GALLOWAY on UNCINULA.

and during the months of September and October it may be found in an active stage on leaves, fruit, tendrils, and growing shoots, covering the same with a whitish, powdery, meal-like growth, which has caused it to receive its characteristic name. The powdery appearance is due largely to the presence of the mycelium and conidia of the fungus, which develop as described below.

Mycelium.—The mycelium consists of thin-walled, nearly hyaline, sparingly septate threads, which are very variable in thickness, but average from 6 to 7μ in diameter. The threads usually run in all directions, but show a tendency to converge at certain points (fig. 1), crossing and recrossing each other until a more or less thickened mat is formed. Although the mycelium does not become noticeably abundant until July, it may be found much earlier by carefully searching vines known to be susceptible to the attacks of the fungus. It occurs on such vines soon after the leaves put out, forming more or less rounded patches, which are difficult to see without the aid of a hand lens.

Haustoria.—At numerous points on the mycelial threads, more or less lobed swellings are formed (figs. 1 and 2). These are somewhat rounded on the upper side, but next to the leaf they are flat, clinging close to the surface. These swellings are the haustoria, and from their under side fine thread-like projections grow out and into the epidermal cells of the host. Once within the cell the end of the haustorial filament swells into a bladder-like body (figs. 3 and 4), which is filled with granular matter like that in the mycelium.

Conidia.—At numerous points the mycelial filaments send up short threads, which bear the conidial spores. These are formed by successive abjunction, from three to twelve being frequently found in one chain (figs. 5 and 6). When mature the conidia are oblong (the largest diameter being 20 to 30μ and the shortest 12 to 18μ), are filled with coarse granulated matter, and frequently contain two or more large vacuoles (figs. 7 and 8), which become more sharply defined as the conidium grows older. The conidia germinate readily in moist air or water, sending out one, and sometimes several, rather thick germ tubes (figs. 9 and 10), which seldom branch unless furnished nutrient material. The production of conidia continues until late in autumn, when the growth of the fungus, as well as that of other vegetation, is checked by frosts.

Perithecia.—Perithecia, in all stages of development, may be found as early as the last of July, occurring in most cases rather evenly scattered over the parts covered by the mycelium. Owing to the close interweaving of the mycelial filaments, it is difficult to make out clearly the changes which take place in the formation of the perithecia.[3] As a rule their development begins at the intersection of two or more mycelial threads. There is little regularity, however, in the matter, and nothing that could be looked upon as a sexual act. Usually short branches, with frequent septa (figs. 11 and 12) grow out from the main hyphæ. These twist around each other, forming a more or less close weft, globose in shape (figs. 13 and 14). At first the bodies are hyaline, but they soon show a brown tint and at the same time become more globular in shape. With increasing age the evidence of the short branches originating from the main hyphæ disappears, and later the walls of the peritheciabe come clearly defined (figs. 15 and 16). Soon after this there is developed from the outer walls of the perithecium eight to thirty appendages (fig. 16), which are at first hyaline and without septa, but later become brown near the base and divided by several cross walls. In the mature perithecia (figs. 17 and 18) the tips of the appendages are hooked and not unfrequently they are branched. The length of the appendages varies greatly, the form on *Vitis vinifera* from the Pacific coast (fig. 19) having especially long ones. Within the perithecia are found the ovate asci containing the spores. There are four to eight, rarely ten, asci in each perithecium, and from four to eight spores in each ascus. From studies made of imbedded material it appears that the dark-colored wall of the perithecium is composed of one or possibly two layers of somewhat thick-walled brown cells. Within this there are one or more layers of colorless cells (fig. 20*a*), which in the early stages at least fit close around the asci, and in some cases seem to extend into the interstices between the latter. These cells take stains in the same manner as the asci. In all the material

[3] After many attempts to find satisfactory material for the study of the development of the perithecia, the best results were obtained by gently boiling for half a minute small fragments of leaves containing fertile hyphæ and young perithecia in a solution of potassic hydrate. After this treatment the mycelium and young and old perithecia easily separate from the leaf and the weft of filaments may be easily floated on a slide, stained, and studied. The most satisfactory stain found was ordinary red ink diluted with 10 to 25 per cent. of its volume of water.

studied the perithecia seemed to be flattened on one side, the flattening sometimes amounting to a concavity. In such cases the asci were compressed vertically and considerably distorted. Doubtless part of the flattening was due to the shrinkage of the tissues during imbedding, but some of it was normal.

One of the principal objects of these studies was to follow the development of the fungus during the winter and to determine if possible when and how the ascospores germinated and the manner in which the host was infected in spring. It was deemed especially desirable to germinate the ascospores, as the evidence as to how this takes place in the Erysipheæ is comparatively meager. Leaves of both ampelopsis and vitis containing the perithecia of the uncinula were collected in the autumn and stored in several ways. Some were placed on the ground and covered with stones and boards, while others were tied up in cheese cloth sacks and the sacks were then thrown on the ground out of doors and tied to stakes in order to prevent them from blowing away. This last method was found to be most satisfactory, as when the leaves were covered with boards they rotted so badly that most of the perithecia were lost. Frequent examinations were made of debris under vines which had been attacked by the uncinula the previous summer. No material of value, however, was obtained in this way, all traces of perithecia disappearing early in December.

The first change of importance in the perithecia was the disappearance of the appendages. After December 1st it was rare to find a perithecium with all of its appendages intact. The hooked ends are usually the first to break off and soon the entire appendage disappears. The asci and spores undergo little change until the last of December, when many of them are found dead or more or less collapsed. All attempts to germinate the ascospores before January failed, and it was only after repeated trials through the months of February and March that success was attained.

The perithecia were from time to time removed from the leaves which had been exposed to the weather and placed in Van Tieghem cells, in the bottom of which was a drop of sterile water. Under these conditions the perithecia were kept properly moistened and could be examined with the microscope at any time. Perithecia collected after January 1st